

**Key Technology Capability Roadmaps:**  
**Performance, Products, and Using Missions vs. Time (continued)**

Time Horizon	Now	5 Years	10 Years	25 Years
Power	<ul style="list-style-type: none"> <li>• 18% efficiency 50W/kg solar cells</li> <li>• 50 Wh/kg Ni-H<sub>2</sub> batteries</li> <li>• 5Wh/kg @ 850 W RTGs</li> <li>• 32kg Pu O<sub>2</sub> RTG fuel (Cassini)</li> <li>• Tolerant to Jupiter radiation belts</li> <li>• Beneficial for all missions</li> </ul>	<ul style="list-style-type: none"> <li>• 25% efficiency 100W/kg solar cells, all solar to SPU for Champollion; Inflatable panels</li> <li>• 100Wh/kg NiH<sub>2</sub> batteries</li> <li>• 12 Wh/kg @ 150 W RTGs</li> <li>• &lt;2kg Pu O<sub>2</sub> RTG fuel for X2000, Pluto, Europa</li> <li>• &lt;10g Pu O<sub>2</sub> for Mars, Europa</li> <li>• Tolerant to Jupiter radiation belts, Mars poles</li> <li>• Beneficial for all missions</li> </ul>	<ul style="list-style-type: none"> <li>• 30% efficiency 150W/kg solar cells, possible all solar outer planet flybys; Inflatable panels</li> <li>• 150Wh/kg NiH<sub>2</sub> batteries</li> <li>• &lt;200g Pu O<sub>2</sub> RTG fuel for outer planet orbiters and probes</li> <li>• &lt;10g Pu O<sub>2</sub> for Mars polar probes, Europa subsurface</li> <li>• Tolerant to Jupiter radiation belts, Mars poles</li> <li>• Beneficial for all missions</li> <li>• Nanosatellite power generation system</li> </ul>	<ul style="list-style-type: none"> <li>• &gt;30% efficiency 200W/kg solar cells, possible all solar outer planet orbiter, Inflatable panels</li> <li>• &lt;200Wh/kg from advanced Li polymer batteries</li> <li>• 20 Wh/kg @ 10 W RTGs</li> <li>• 100g Pu O<sub>2</sub> RTG fuel or light reactor or ~100s of A<sub>1</sub> NEP</li> <li>• Tolerant to Jupiter radiation belts, Mars poles</li> <li>• Beneficial for all missions</li> </ul>
Sample Acquisition and Return	<ul style="list-style-type: none"> <li>• Mobile science labs with ~5 integrated instruments for planets, comets, space physics</li> <li>• Organic compound detection</li> <li>• Subsurface penetrators with high-G-tolerant instruments (Mars 98/01/03 and Champollion)</li> <li>• Comet coma sample return (Gardus)</li> </ul>	<ul style="list-style-type: none"> <li>• Mini-biochemistry labs: detect amino acid chirality; wet chemistry lab; MEBMS sensors on a chip</li> <li>• Mini-geochronology sensor with miniature mass spec. and laser-ablated samples</li> <li>• Comet nucleus and asteroid sample returns</li> <li>• Enabling for Mars program</li> </ul>	<ul style="list-style-type: none"> <li>• Long-range airborne and surface integrated mobile science labs with up to ten physical, chemical and biological measurements at and below planet, satellite, asteroid, or comet surfaces</li> <li>• Hardened electronics and sensors working at temperatures found on Mars, Venus, Titan, comets, and asteroids</li> <li>• Pristine rocks, soils from Mars, comets, asteroids</li> <li>• Smart instruments (with humans) for surveys</li> <li>• Enabling technology for Mars, Venus, Titan, and small bodies</li> </ul>	<ul style="list-style-type: none"> <li>• Long-lived mobile science labs capable of multidiscipline interactive measurements</li> <li>• Sophisticated data analysis, fusion, and information extraction</li> <li>• Multidimensional sensors on a chip using MEBMS technology</li> <li>• Pristine samples of outer planets and their satellites</li> <li>• Smart autonomous instruments for surveys, and samplers (without humans)</li> <li>• Enabling for landers on solar system bodies</li> </ul>
Science Instruments	<ul style="list-style-type: none"> <li>• 100μ features for electromechanical systems</li> <li>• Integrated instrument suite with common electronics (DS-1 and MICAG at 12kg, 12W, #6M)</li> </ul>	<ul style="list-style-type: none"> <li>• 25μ features in electromechanical micro-instruments (e.g., hydrometer)</li> <li>• Optical and infrared space-based Interferometry</li> <li>• Enabling for Origins and SEU missions</li> <li>• Silicon Strip Detector Tracker with larger detector size (6° waters) and increased effective area for energies &gt;1 GeV for GLAST mission</li> <li>• Cesium Iodide Calorimeter with an 80 crystal module packing and a dynamic range of 80 MeV–80 GeV for GLAST</li> <li>• Advanced Scintillating Fiber Tracker Calorimeter with a fiber output of 120 photons and a tracker conversion efficiency of 80% for GLAST</li> </ul>	<ul style="list-style-type: none"> <li>• 10μ devices used in electromechanical-optical instruments such as weather station</li> <li>• Higher resolution, wide band width imaging and spectroscopy SAR and radar sounding</li> <li>• Inflatable structures and optics for science craft</li> <li>• Matched electronic and sensor operating temperature for integration</li> <li>• Enabling for Origins and SEU missions</li> <li>• Large format, low noise near infrared and far-infrared detector enables NGST</li> <li>• High-resolution, large-area reflective gratings and matched resistive gate CCD detector system enabling for Constellation-X</li> <li>• Accelerometers with a sensitivity less than 10(–13)g at 300 seconds enabling LISA</li> <li>• Cryogenic coolers achieving ranges of 2–20 degrees K with little or no vibration, low power, and long life enabling NGST and Constellation-X</li> </ul>	<ul style="list-style-type: none"> <li>• Nanometer-scale optical, quantum, or biological devices</li> <li>• Integrated sensors from γ-ray to MW with automated analysis and event-driven response</li> <li>• Automated continuous surveys of solar system with &lt;100kg S/C and 10 W per suite</li> <li>• Enabling for Origins and SEU missions</li> </ul>